UNITED STATES PATENT APPLICATION

OF

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FOR

PROJECTOR

[0001] This application claims the benefit of the Korean Application No. P2000-84717 filed on December 28, 2000, which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a projector.

Background of the Related Art

[0003] The projector enlarges, and projects a small picture on a small display inside of the projector by using a projection lens system to a large sized screen, to display a large sized picture. There are a front projection type in which the picture is displayed on a front face of the screen, and a rear projection type in which the picture is displayed on a rear face of the screen. As a typical one of the latter, there is the projection television. As the small display in the projector that displays the small picture, LCD (Liquid Crystal Display) and DMD (Digital Micromirror Device), and the like are employed. The LCD is provided with a polarization beam converter as shown in FIGS. 1A and 1B for displaying the picture by using a linearly polarized light.

[0004] In order to fabricate a small sized projector, and enhance a visibility of the large picture displayed on the large sized screen, it is required to fabricate the polarization beam converter thinner, as well as minimize an optical loss of the polarization beam converter.

[0005] FIGS. 1A and 1B illustrate related art polarization beam converters, FIG. 2 illustrates operation of the polarization beam sprite array in FIG. 1A, FIGS. 3A and 3B illustrate details of the polarization beam sprite array in FIG. 1A, FIG. 4 illustrates a light source with a parabolic reflector, FIG. 5 illustrates a light source with an elliptic reflector, and FIG. 6 illustrates a beam distribution of beams focused by the lens array in FIG. 1A.

[0006] Referring to FIGS. 1A and 1B, the related art polarization beam converter is

provided with a first lens array 2, a second lens array 4, and a polarization beam sprite array 6 facing an optical output surface of the second lens array 4.

[0007] The first lens array 2, or the second lens array 4 focuses white beams of lights inclusive of P wave and S wave onto a plurality of focusing points. To do this, the first, or second lens array 2, or 4 has a matrix of a plurality of lenses.

[0008] In the meantime, the polarization beam sprite array 6 transmits an 'S' wave, and converts a 'P' wave into 'S' wave and transmits the converted 'S' wave among the beams from the second lens array 4. To do this, the polarization beam sprite array 6 has polarization beam split planes 10 and polarization beam reflection planes 12, both sloped with respect to an optical input surface and an optical output surface as shown in FIG. 2, and half wavelength plates 8 attached to the optical output surface.

[0009] The polarization beam split plane 10 only transmits the P wave and reflects the S wave among the white beams of lights from the second lens array 4. The P wave passed through the polarization beam split plane 10 is converted into an S wave by the half wavelength plate 8. On the other hand, the S wave reflected at the polarization beam split plane 10 is reflected at the reflection plane 12.

[0010] That is, the entire beams of lights inclusive of the P wave and the S wave passed through the polarization beam sprite array 6 are converted into the S wave. The polarization beam sprite array 6 has two parts to be symmetric with respect to a center part 14 thereof as shown in FIG. 3A.

[0011] Referring to FIGS. 3A and 3B, the white beams of lights incident on the first lens array 2 from the light source (not shown) are incident on the first lens array in parallel to one another. To do this, the related art polarization beam converter employs a lamp 18 with a parabolic reflector 16. However, even the white beams from the lamp 18 with the

parabolic reflector 18 include non-parallel beams. As shown in FIG. 3B, the second lens array 4 serves to compensate for a loss caused by the non-parallel beams.

[0012] The lamp 18 with the parabolic reflector 16 has an optical efficiency poorer than a lamp 20 with an elliptic reflector 22 shown in FIG. 5.

[0013] It will be explained in detail, assuming that a diameter of the parabolic reflector 16 is Dp and a diameter of the elliptic reflector is De. The lamp 18 with the parabolic reflector 16 directs the beams of lights forward in parallel, i.e., the parabolic reflector 16 is required to have a slope for directing the beam from the lamp 18 forward in parallel.

[0014] On the other hand, the lamp 20 with an elliptic reflector 22 directs the beams of lights such that the beams are focused at a plane in front of the lamp 34. Accordingly, the elliptic reflector 22 is required to have a slope greater than the parabolic reflector 16 so that the beams from the lamp 20 are focused on the plane in front of the lamp 20. That is, because the lamp 20 with the elliptic reflector 22 can reflect more beams, the lamp 20 with the elliptic reflector 22 has an optical efficiency higher than the lamp 18 with the parabolic reflector 16.

[0015] If the lamp 20 with the elliptic reflector 22 and the lamp 18 with the parabolic reflector 16 have the same optical efficiency, the diameter of the elliptic reflector 22 can be made smaller than the parabolic reflector 16, to reduce a size of the elliptic reflector 22. However, since the related art projector requires parallel beams, the lamp 20 with the elliptic reflector 22 can not be employed therein. Therefore, the related art projector has a limitation in fabricating a thinner projector.

[0016] Moreover, there are no beams incident on a center part of the related art polarization beam sprite array 6. That is, the beams from the first lens array 2 and the

second lens array 4 are incident on the polarization beam sprite array 6 in symmetry with respect to a center part 14 thereof. Consequently, no beams pass through the center part 14 of the related art polarization beam sprite array 6. Accordingly, there has been a problem in that a uniformity of the beams becomes poorer even if a position of the polarization beam sprite array 6 is changed, slightly.

[0017] Furthermore, the related art polarization converter is provided with lens arrays having a plurality of lenses. There are optical losses between the plurality of lenses of the lens arrays. However, if the number of the lenses provided in the lens array is reduced, a production cost of the projector increases because a thickness of the polarization converter relatively increases. Particularly, since alignment of the lens arrays influences to an optical conversion efficiency significantly, much time is required for an accurate assembly.

[0018] In addition to this, because the related art projector uses parallel beams, the beams are not focused at one point. Therefore, in order to employ only one sheet of display (i.e., for providing a color wheel), a first optical system for focusing the beams, and a second optical system for diverging the focused beams again are required, additionally. Accordingly, the fabrication of a thinner projector has been difficult in the related art.

SUMMARY OF THE INVENTION

[0019] Accordingly, the present invention is directed to a projector that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

[0020] An object of the present invention is to provide a projector which permits fabrication of a thinner projector.

[0021] Another object of the present invention is to provide a projector which can minimize an optical loss.

[0022] Additional features and advantages of the invention will be set forth in the

description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

[0023] To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, the projector employs a rod lens for making a distribution of incident beams uniform. The employment of the rod lens permits to employ a lamp with an elliptic reflector that allows fabrication of a thin projector.

[0024] In another aspect of the present invention, there is provided a projector including a light source for emitting beams of lights, a rod lens for receiving the beams of lights from the light source and making a distribution of the beams uniform, and a polarization beam converter for receiving the beams from the rod lens. The polarization beam converter has a lens part for receiving the beams from the rod lens and focusing onto a plurality of focusing points, and a polarization beam sprite array receives the beams inclusive of a P wave and an S wave, and forwards the P wave as it is, and converting the P wave into the S wave before forwarding.

[0025] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention:

In the drawings:

FIGS. 1A and 1B illustrate related art polarization beam converters;

FIG. 2 illustrates operation of the polarization beam sprite array in FIG. 1A,

FIGS. 3A and 3B illustrate details of the polarization beam sprite array in FIG. 1A;

FIG. 4 illustrates a light source with a parabolic reflector;

FIG. 5 illustrates a light source with an elliptic reflector;

FIG. 6 illustrates a beam distribution of beams focused by the lens array in FIG. 1A;

FIGS. 7A and 7B illustrate polarization beam converters in accordance with a preferred embodiment of the present invention;

FIG. 8 illustrates a detail of operation of the rod lens shown in FIG. 7A;

FIG. 9 illustrates distribution of beams focused by the illumination lenses in FIG. 7A;

FIG. 10 illustrates a detail of operation of the polarization beam sprite array in FIG. 7A; and,

FIG. 11 illustrates a diagram of an optical system in which a polarization beam converter is arranged to provide a P wave at a final stage.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0027] Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings FIGS. 7A – 10.

[0028] FIGS. 7A and 7B illustrate polarization beam converters in accordance with a preferred embodiment of the present invention, FIG. 8 illustrates a detail of operation of the rod lens shown in FIG. 7A, FIG. 9 illustrates distribution of beams focused by the illumination lenses in FIG. 7A, and FIG. 10 illustrates a detail of operation of the polarization beam sprite array in FIG. 7A.

[0029] Referring to FIGS. 7A and 7B, the projector in accordance with a preferred embodiment of the present invention includes a rod lens 24, a first illumination lens 26 and a second illumination lens 28 for focusing beams from the rod lens 24 at a particular location, and a polarization beam sprite array 30 facing an optical output surface of the second illumination lens 28. The first illumination lens 26, the second illumination lens 28, and the polarization beam sprite array 30 facing the optical output surface of the second illumination lens 28 compose a polarization beam converter.

[0030] In the unexplained reference symbols in FIGS. 7A and 7B, 32 denotes a reflection planes, 38 denotes center parts of the first illumination lens 26 and the second illumination lens 28, and 40 denotes a center part of the polarization beam sprite array 30.

[0031] The rod lens 24 makes distribution of the beams focused from a light source and incident thereon uniform. As shown in FIG. 8, the beams from the light source is focused onto an optical input surface 34 of the rod lens 24.

[0032] The beams incident on the incident surface of the rod lens 24 are totally reflected inside of the rod lens 24, that makes the distribution of beams uniform at an optical output surface of the rod lens 24.

[0033] In the meantime, referring to FIG. 6, beams incident on the polarization beam sprite array 30 are split into preset groups. To do this, the optical output surface 36 of the rod lens 24 is required to have an area equal to, or smaller than an area of the optical input surface 34.

area of optical input surface ≥ area of optical output surface -------------------------- (1)

[0034] When the optical output surface 36 of the rod lens 24 has an area smaller than the area of the optical input surface 34, a degree of optical split is improved. The beams from the rod lens 24 are focused onto a plurality of focus points as shown in FIG. 9 by the

first illumination lens 26 and the second illumination lens 28.

[0035] Referring to FIG. 9, the beams from the first illumination lens 26 and the second illumination lens 28 are symmetric with respect to center parts 38 of the first illumination lens 26 and the second illumination lens 28, with large quantities of the beams concentrated on the center parts 38. Accordingly, the deterioration of the beam uniformity caused by fine movement of the first illumination lens 26, the second illumination lens 28, and/or the polarization beam sprite array 30 can be prevented.

[0036] In the meantime, since the beams from the second illumination lens 28 are incident on the center part 40 of the polarization beam sprite array 30, the center part 40 of the polarization beam sprite array 30 has a configuration as shown in FIG. 10.

[0037] Referring to FIG. 10, the center part 40 of the polarization beam sprite array 30 has polarization beam split planes 42 and polarization beam reflection planes both sloped with respect to the optical input surface and the optical output surface of the polarization beam sprite array 30, and a half wavelength plate 32 attached to the optical output surface of the polarization beam split plane 42.

[0038] The polarization beam sprite array 30 is symmetric with respect to the center part 40, with two polarization beam split planes 42 forming a triangular section in the center part 40. The polarization beam split planes 42 receives the white beams from the second illumination lens 28, and transmits only P wave and reflects S wave. The P wave transmitted the polarization beam split planes 42 is converted into the S wave by the half wavelength plate 32, and forwarded. On the other hand, the S wave reflected at the polarization split planes 42 is reflected at the reflection surface 44, and forwarded as it is. That is, all the white beams inclusive of the P wave and S wave passed through the polarization beam spite array 30 are converted into S wave.

[0039] As explained, the rod lens 24 in the projector in accordance with a preferred embodiment of the present invention requires focused beams incident thereon, the lamp 20 with elliptic reflector 22 shown in FIG. 5 may be employed. Therefore, the projector of the present invention has an optical efficiency higher than the projector having the lamp 18 with the parabolic reflector 16, and permits fabrication of a thinner projector.

[0040] Moreover, there may be a color wheel provided between the rod lens 24 and the light source additionally in the present invention. That is, without addition of an optical system, the color wheel may be provided in front of the rod lens 24 at which the beams are focused. Accordingly, the projector of the present invention permits to fabricate a thinner projector as there is no additional optical system.

[0041] Furthermore, the projector in accordance with a preferred embodiment of the present invention can prevent the light loss occurred at the related art lens array because the beams can be focused by using the first illumination lens 26 and the second illumination lens 28 without the lens array employed in the related art projector.

[0042] FIG. 11 illustrates a diagram of an optical system in which a polarization beam converter is arranged to provide a P wave at a final stage.

[0043] Referring to FIG. 11, half wavelength ($\lambda/2$) plates are fitted to parts of the polarization beam converter where the S waves split by the polarization beam converter 30 are provided, to provide P waves on the whole as the P waves transmitted through the polarization beam converter as they were proceed intact.

[0044] As has been explained, the projector of the present invention permits to fabricate a thinner projector because the lamp with the elliptic reflector can be employed in place of the lamp with the parabolic reflector in the related art. Also, the employment of the lamp with the elliptic reflector, a color wheel can be employed without addition of an optical

system. The color wheel is fitted between the light source and the rod lens, for splitting at least on color beam from the beams. Also, the focusing of the beams only by using the illumination lens instead of the related art lens array onto the polarization beam sprite array minimizes the light loss.

[0045] It will be apparent to those skilled in the art that various modifications and variations can be made in the projector of the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.